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Influences on the decision to authorize wildland fire use

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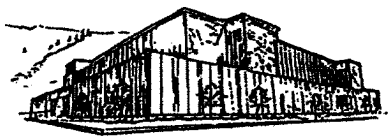

INFLUENCES ON THE DECISION TO AUTHORIZE WILDLAND FIRE USE

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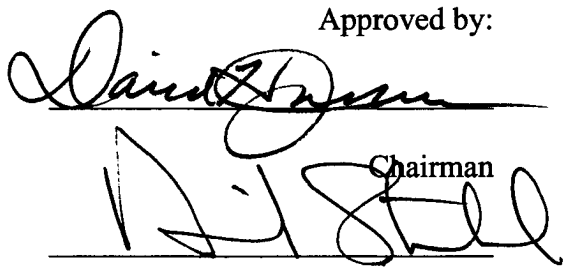

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Influences on the decision to authorize Wildland Fire Use

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ABSTRACT

Federal wildland fire policy and program reviews following the 1994 and 2000 fire seasons required recognizing fire as a natural process and reducing hazardous fuel accumulations. To meet this requirement, new policy encouraged managing natural ignitions to meet resource benefits (called Wildland Fire Use, WFU). However, mechanical treatments and prescribed burning comprise the majority of fuel reduction treatments effected to date. Budget constraints and the need for repeated treatments suggest that successful fuel and ecosystem management hinges on expanding the WFU program.

The decision to authorize WFU in the U.S. Forest Service ultimately rests with the line officers, typically the district rangers. The so-called 'go/no go' decision constitutes a time-critical risk assessment. The factors weighing in to this risk assessment underpin the feasibility of expanding the WFU program.

This study aimed to determine the influences on the line officers' go/no go decision. This study conducted a telephone survey of all the U.S. Forest Service district rangers with the authority to use WFU in the Northern, Intermountain, and Southwestern Regions. The census was completed during February of 2005 and obtained an 85 percent response rate.

This study used classification and regression tree (CART) analysis to examine the data collected. Personal commitment to the WFU program provided the primary classifier for 91 percent of the district rangers who authorized WFU. External factors, negative public perception, resource availability, and a perceived lack of support from the agency surfaced as the main disincentives to authorizing WFU.

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1. INTRODUCTION

Effective fire suppression over the last 100 years has led to changes in forest structure. The fuel buildup resulting from fire exclusion has left millions of acres prone to higher severity wildland fires than those that historically visited the landscape. Active fire seasons in 1994 and 2000 drew attention to this unanticipated consequence of fire suppression and instigated a shift in national fire policy towards hazardous fuel reduction. In an attempt to provide performance measures and reduce the immediate likelihood of 'catastrophic' wildfire, agency direction has focused on mechanical treatments and prescribed burning. While these treatments do alter the forest structure responsible for the higher intensity fire events, they do not remedy the underlying problem of fire exclusion.

Wildland Fire Use (WFU) is the fire management strategy that allows natural ignitions to burn in predetermined locations under scripted conditions. This strategy allows fire to assume its role as a vital ecosystem process. Originally conceived to allow natural processes to dominate in designated Wilderness areas, WFU has predominantly been cast as a wilderness management tool. However, changes to national fire policy since 1995 have encouraged the recognition of fire as a natural process. This new direction, in conjunction with the ability of WFU to restore both structure and process, suggests that WFU should assume a more prominent role as a fuel management tool. Although WFU is not a viable option on all lands, expanding its use would help avoid a hopeless exercise: running after symptoms rather than addressing the root problem.

The decision to authorize WFU rests with agency administrators. The need for managerial accountability has created a decision process that places all of the authority (and consequent liability) on the administrator. Specifically in the US Forest Service (USFS), District Rangers are the line officers most frequently presented with the 'go/no go' decision on whether to allow WFU. The USFS has stated the intent of restoring fire to the landscape. Consequently, understanding the drivers of the so-called 'go/no go' decision assumes critical importance.

1.1. Background

1.1.1. Smokey's legacy

Federal fire policy began focusing on suppression shortly after the creation of the National Park System in 1872 (Stephens and Ruth 2005). This paradigm grew to encompass not only patrols in the newly created parks but also interpretation of the Organic Administration Act of 1897 that created the Forest Service (Nelson 1979). Large fires across the inland Northwest only a few years later, in 1910, further justified wildfire suppression (Arno and Fiedler 2005). Perhaps one of the most effective public relations figures ever created, Smokey Bear, objectified the need to eliminate fire to the American public. This bear, armed with a shovel, a plea ("Only you can prevent forest fires"), and an imploring stare, successfully placed forestland preservation into firefighters' hands.

The resulting fire suppression organization was perhaps too effective. Rumblings of fire exclusion's negative effects followed on the tails of the policy's adoption (Koch 1935,

Weaver 1943). Starting in 1963, detrimental loss of the early seral species maintained by fire was tied to fire suppression (Leopold et al. 1963). Shortly thereafter, passage of the Wilderness Act (1964) codified the need to preserve natural processes in the designated Wilderness areas. This nod to natural processes opened the door for the prescribed natural fire (PNF) program, through which lightning strikes could burn under certain conditions to achieve resource benefits.

Despite inklings that fires belonged on the landscape, suppression expenditures jumped starting in the 1970s (Nelson 1979). The 1988 fire season drew national attention to the developing tinderbox, as fires burned through Yellowstone National Park and the Scapegoat Wilderness in northern Montana. Policy and program review following these large fires put a moratorium on the prescribed natural fire program. These fires also initiated a trend towards more, harder to control wildfires, with successively more dramatic fire seasons in 1994, 2000, 2001, and 2002 (Stephens and Ruth 2005).

1.1.2. Policy solutions to fire exclusion

Federal fire policy reviews initiated after the 1994 and 2000 fire seasons addressed the need to restore fire to the landscape and, more specifically, to mitigate hazardous fuel accumulations in fire-adapted ecosystems. Although the text of these policies acknowledges fire as an essential component of many ecosystems, implementation has focused on remedying the fuel accumulations resulting from suppression.

The 1995 Federal Wildland Fire Management Policy and Program Review followed an active fire season that left 34 fatalities in its wake. For the first time, the guiding principles established by the review determined that the planning process would incorporate "the role of wildland fire as an essential ecological process and natural change agent" (NWCG 1995a). Specific policies developed from these guiding principles further stated:

- fire as a critical natural process will be integrated into land and resource management plans and activities on a landscape scale;
- wildland fire will be used to protect, maintain, and enhance resources and as nearly as possible, be allowed to function in its natural ecological role.

Although this language appears to encourage managing wildland fire for resource benefits, this policy has translated into a goal of reducing fire hazard by using mechanical treatments and prescribed burning (NWCG 1995a).

Direction from the 1995 policy review increased the number of acres treated to reduce fuels from fewer than 500,000 in 1994 to over 2.4 million in 2000 for both the Department of Interior Bureau of Land Management (BLM) and the Forest Service (USDA-USDI 2000). Despite this increase in fuel treatments, the 2000 fire season had an inauspicious start. The Cerro Grande prescribed fire escaped, and burned 235 homes and 48,000 acres. The remainder of the fire season followed this lead, with twice the 10-year average acreage burning between May and September (USDA-USDI 2000). Another federal wildland fire policy review ensued.

The 2000 review of 1995 federal fire policy reaffirmed the need to incorporate fire as a critical ecosystem component in the planning process (NWCG 2001), and implementation of this goal again has centered on fuel reduction. "Managing the impacts of wildfires on communities and the environment: a report to the President in response to the fires of 2000," prepared by the Departments of Agriculture and Interior, recommended increasing funding for hazardous fuel reduction. This report also identified the most significant challenge to implementation as the substantial increase in the acreage of forest lands to receive treatment (USDA-USDI 2000). This report's recommendations, in conjunction with congressional funding, formed the National Fire Plan that currently provides implementation guidance for federal fire policy (NWCG 2001).

1.1.3. Agency performance rating tied to hazardous fuel reduction

Implementation of the 1995 and 2001 policy revisions has focused restoration efforts on the ecosystem types most adversely affected by fire exclusion. Fire suppression has led to the greatest forest structural changes in low-elevation, dry ecosystems maintained by fire regimes I and II (Mutch 1994)[1]. These areas, which have skipped one to two fire events in the past 80 years, now exhibit greater stand densities, fewer seral species, and higher crown-fire potential (e.g. Mutch 1994, Mutch and Cook 1996, NWCG 1998). This apparent forest health problem is juxtaposed to increasing housing development in

[1] Fire regimes describe the role fire plays in an ecosystem and are characterized by time between fire events (frequency) and effect on overstory vegetation (severity) (Agee 1993). Five fire regimes distinguish between low-severity and stand-replacement severity burns that occurred every 0-to-35 years (fire regimes I and II), mixed-severity and stand-replacement severity burns every 35-to-100 years (fire regimes III and IV), and stand-replacement severity burns that occurred less than once every 200 years (fire regime V, Schmidt et al. 2002).

forest areas. The Wildland Urban Interface (WUI), defined as areas where houses either intermingle with or sit adjacent to contiguous vegetation, grew by 30 percent between 1990 and 2000 in the intermountain West alone (Stewart et al. 2005).

Federal fire policy has focused on mitigating the effects of decades of fire suppression; implementation has followed suit. For example, the National Fire Plan comprises one of the five key performance areas for the Forest Service in complying with the Budget and Performance Initiative of the President's Management Agenda (USDA 2004a). Acres of hazardous fuels in condition classes 2 or 3[2] in fire regimes I, II, or III, and acres of forest health protected are two of the performance indicators used. Similarly, the Forest Service's strategic plan for fiscal years 2004-2008 identifies the first goal for these four years as "reducing the risk from catastrophic wildfires" by improving the health of the Nation's forests and grasslands (USDA 2004b). Performance measures identified to achieve this goal include increasing the number of acres treated to reduce hazardous fuels, and increasing the number of acres treated per million dollars gross investment (USDA 2004b). Attainment of performance targets must result from management actions tied to budget line items. Mechanical treatments and prescribed burns constitute budgetable activities and performance therefore rests on acres treated using these two methods.

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[2] Fire Regime Condition Class indicates the degree of departure from the historical fire regime. Condition classes 2 and 3 refer to areas that have missed more than one fire event (Schmidt et al 2002). Condition class indicates the extent to which fire exclusion has altered key ecosystem components: vegetation structure, species composition, and potential fire behavior characteristics (Hann and Bunnell 2001).

Not only have performance measures been linked to hazardous fuel reductions, but budgets have been too. The Healthy Forests Initiative authorized in 2002 and the Healthy Forests Restoration Act of 2003 put location restrictions on the projects they fund. Fifty percent of the funding for projects conducted under their auspices must go to fuel reduction in the wildland-urban interface. Fiscal year 2005 program direction for the USFS specifies that managers should maximize opportunities to implement projects that will reduce hazardous fuels.

Despite this effort to address fuel accumulation, three problems arise. First, fuels still accumulate at two to three times the current treatment rate (USDA 2004a). Second, the most accessible, and therefore least expensive, treatments may have been done (Calkin, personal communication 2005, GAO 2005). In the current climate of budget rescissions, it is unlikely that all the acres that need treatment to remedy 100 years of fuel buildup will receive it. Third, since these treatments focus mostly on the 0-to-35 year return interval fire regimes, one-time treatments will not resolve the problem of fuel accumulation. These areas will need maintenance treatments on regular intervals to truly resolve the forest structure problems resulting from fire exclusion (Black 2004). This scenario seems unlikely given the difficulty of treating the initial acreage even once.

1.1.4. Wildland Fire Use as a means to restore process

Minimizing future damage to communities and key ecosystem components relies on reducing hazardous fuel accumulation (e.g., Miller 2003). However, this fuel buildup stems from years of fire suppression. While focusing on fuel reduction provides concrete

objectives and performance measures, it does not address the root problem. Increasing the acreage with fire allowed to play its historical role, in conjunction with treating the symptoms of fire exclusion, will begin to resolve the broader fuel management problem.

Prescribed natural fire (PNF) is the fire management strategy that allows natural ignitions to burn under predetermined conditions. This management option grew out of the Wilderness Act of 1964 that mandated natural processes to dominate within Wilderness areas (Mutch 1995). The National Park Service allowed the first PNF to burn in Sequoia-Kings Canyon National Park in 1968 (Stephens and Ruth 2005) and USFS policy changed in 1971 to allow PNF in designated Wilderness areas (Benedict et al. 1991). This new option of wilderness fire broke the grip that suppression had on fire management and yet the wilderness ideology drove the use of PNF more than a desire to treat fuels (Pyne 1995).

Prescribed natural fire was re-baptized as Wildland Fire Use (WFU) in the 1995 Federal Wildland Fire Management Policy and Program Review (NWCG 1995a). Following this policy review, managing natural ignitions for resource benefits has largely remained a wilderness management tool (Kilgore and Nichols 1995). With National Forests expanding the acres approved for WFU outside of Wilderness boundaries (see *Results* section of this paper), it seems that WFU can assume a more prominent role in fuel management. As a tool that restores process and in so doing begins to remedy structure, WFU can help address the fundamental cause of the current fire management problem (Miller 2003, Stephens and Ruth 2005).

1.1.5. The go/no go decision

The decision to allow WFU (called 'go/no go') can only come after meeting three planning requirements (NWCG 1995a). The Land/Resource Management Plan (L/RMP) provides general direction for the wildland fire management direction. In the USFS, the L/RMP corresponds to the Forest Plans that must go through a public comment period (36 CFR 219). Fire Management Plans (FMP) tier to this document. These plans identify the fire management strategies available for every burnable acre. For areas determined as eligible for wildland fire use by the FMP, managers must create guidelines that specify the burning conditions acceptable for wildland fire use (NWCG 2003).

With these planning requirements satisfied, managers can evaluate individual lightning strikes for potential resource benefits. Initial assessment of individual fires follows the process outlined by the Wildland Fire Implementation Plan Stage 1 (WFIP1). The WFIP1 process documents the elements considered in the go/no go decision and sets a periodic needs assessment schedule. The Stage 1 framework can guide management of a WFU event with low potential for spread and negative impacts (NWCG 2005).

If the periodic assessment indicates a changing fire situation, then planning will progress to the Wildland Fire Implementation Plan Stage 2 (WFIP2). This stage provides a planning structure for larger, more active fires with the potential for greater geographic extent than Stage 1 WFU events (NWCG 2005).

A WFU fire that exceeds the planning capacity of the Stage 2 plan can transition to the Wildland Fire Implementation Plan Stage 3 (WFIP3). This stage defines the management actions required in response to increasing fire activity, a potential for longer duration, or a need for increased management activity. The WFIP3 presents a detailed planning effort that addresses management objectives and constraints in detail. Stage 3 also requires a quantitative risk assessment and cost estimates (NWCG 2005).

Federal policy designates the agency administrator as the final authority on the go/no go decision (NWCG 2005). In the USFS, for example, line officers act as the agency administrator (USDA-FS 2000) and assume both the authority and the legal and career liabilities for the decision to allow WFU.

Increasing WFU utility as a fuel management tool for the USFS hinges on line officers authorizing its application. Understanding the decision process underpinning WFU will provide critical insight into the feasibility of its use as a fuel management tool in Wilderness, and perhaps more importantly, outside of Wilderness.

1.1.6. Factors influencing the go/no go decision: policy direction

Federal wildland fire policy provides a formal framework for the go/no go decision. The Forest Service Manual stipulates that firefighter and public safety take precedence over any other concern (5103.1), and that a WFU project may only be implemented with trained and qualified personnel (5145.1).

The current Wildland Fire Use Implementation Procedures Reference Guide (NWCG 2005) identifies additional elements that must enter the decision process. Only natural ignitions may be managed for resource benefits, and each wildland fire may have only one objective. If at any point a WFU fire ceases to meet the stated objectives, it must be managed for suppression objectives. Similarly, if a WFU fire combines with a wildland fire managed for suppression objectives, the suppression objective will override resource objectives.

Decision criteria checklist

For wildland fires that meet the criteria above, the Wildland Fire Implementation Plan Stage 1 process (WFIP1) provides an evaluation of the candidate fire's physical elements. This evaluation establishes whether the fire lies within the prescriptions outlined in the fire management plan and WFU guidebook. The WFIP1 also includes a Decision Criteria Checklist (NWCG 2005). A 'yes' answer to any criterion indicates a suppression response. This checklist leads the agency administrator through a decision process that includes five criteria:

1. threat to life, property, or public and firefighter safety that cannot be mitigated;
2. potential effects on cultural and natural resources outside the range of desired effects;
3. relative risk indicators and/or risk assessment results unacceptable to the appropriate agency administrator;
4. other proximate fire activity that limits or precludes successful management of the fire;

5. other agency administrator issues that preclude wildland fire use.

The relative risk assessment identified in number 3, above, involves a combination of risk to values, fire hazard, and the probability of the fire becoming an active event. Risk to values reflects a combination of natural and cultural concerns, location of the fire with respect to values, and social and economic concerns. Fire hazard collapses fire regime condition class, expected fire behavior, and potential fire size into one variable. Probability indicates the combined effects of time of season, barriers to fire spread, and seasonal severity (NWCG 2005).

Agency administrators have 8 hours from ignition detection and strategic size-up to complete the qualitative risk assessment included in the WFIP1. Up until January of 2005, line officers faced a 2-hour time constraint on the go/no go decision (NWCG 1998, 2005).

1.1.7. Factors influencing the go/no go decision: informal studies

Federal fire policy and the Wildland Fire Use implementation guidelines provide elements that agency administrators must consider in their go/no go decision. As documented in the Decision Criteria Checklist, 'other issues' can enter into the decision. Several authors peripherally address these issues, which fall into six broad categories: attitude towards risk, potential impact to resources, public attitudes, staffing, cost, and land stewardship.

Personal risk posture and the risk of a WFU event escaping surfaced most frequently as barriers to authorizing WFU (Arno and Brown 1991, Bradley 1995, Bunnell 1995, Calkin et al. forthcoming, Daniels 1991, Kilgore 1991, van Wagtendonk 1995, Williams 1995). This risk assumes greater importance when combined with potential damage to natural resources, private property, or commodities such as timber (Czech 1996, Parsons and Landres 1998). The potential professional consequences of a WFU fire escaping and damaging these resources could also enter the decision process (Arno and Fiedler 2005, Bunnell 1995, van Wagtendonk 1995).

Beyond career impacts, failure to exercise due care under the circumstances (negligence) could indicate liability for ensuing damages (White 1991). In the case of employee injury, decision-makers could be held liable without evidence of negligence (Stanton 1995).

The possibility of a WFU event damaging other resources and property adds to the career risk inherent in the decision to authorize WFU.

Lack of public support (Czech 1996, Daniels 1991), coupled with the documented need for public buy-in for successful fire and fuels management (Shindler and Toman 2003, Weible et al. 2005) could also factor into the agency administrator's decision. Air quality concerns from both regulatory and public opinion perspectives could constitute "other agency administrator issues" (Arno and Brown 1991, Czech 1996, Parsons and Landres 1998).

Daniels' (1991) analysis of his decision to authorize the Canyon Creek PNF in 1988, a fire that subsequently exceeded its authorized perimeter and helped instigate the 1988 Federal Wildland Fire Policy and Program Review, revealed additional influences. The managerial endurance required to commit to managing a WFU event for an extended and indeterminate period enters into the go/no go decision (Bonney 1998, Daniels 1991, Tomascak 1991). Part of the problem with committing to managing a WFU event for an extended period relates to staffing. Both Benedict et al. (1991) and Daniels (1991) indicate that having highly qualified personnel available in adequate numbers weighs heavily in the decision to use WFU.

While these authors predominantly suggest factors that tip the decision towards "no go," others indicate influences in favor of authorizing WFU. Anecdotal evidence of cost savings through wildland fire use suggests this as a possible motivator (Bonney 1998, Calkin et al. forthcoming, Czech 1996, Daniels 1991). In addition to reducing costs, the desire to minimize firefighter exposure to the dangers of wildland fires could also influence the go/no go decision (Bonney 1998). Finally, a dedication to stewardship that dictates a commitment to restoring fire could inspire a 'go' decision (Arno and Fiedler 2005, Jolly 1995, Pyne 1995).

1.2. Literature Review

Federal policy and agency directives establish several of the elements agency administrators must consider in their go/no go decision. Beyond these sideboards,

published works by several authors address the potential factors affecting the decision to use WFU.

1.2.1. Studies on decision elements

Four studies provide evidence for the factors influencing the decision to use WFU. One of these studies assessed factors influencing fire managers' risk behavior (Cortner et al. 1990), two studies examined barriers to prescribed burning (Cleaves et al. 2000, NWCG 1995b), and another explored information needs for wildland fire and fuel management (Miller and Landres 2004).

Cortner and others (1990) investigated influences on fire managers' risk behavior. This research conducted a mail survey of 994 USFS fire managers in five western regions (Northern, Southwestern, Intermountain, Pacific Southwest, and Pacific Northwest). The scenarios included in the questionnaire looked to identify the fire managers' risk behavior in the context of escaped wildfires, prescribed burns, and long term fire budget planning. The 837 respondents indicated that safety considerations, resources at risk, and changes in public opinion had the most effect on shifting decisions towards risk aversion. The questions specifying safety considerations hypothesized changes in personnel availability and personnel experience. Public opinion specifically related to trust in agency professionalism had more effect on decisions than criticism by influential groups or concerns over arousing public anger. Although this study investigated effects on fire managers' risk-behavior in the contexts of escaped wildfire, prescribed burning, and long

range fire planning, factors such as safety considerations, resources at risk, and concerns for agency professionalism could also influence the WFU decision-making process.

An informal survey conducted in 1995 by the National Wildfire Coordinating Group's Prescribed Fire and Fire Effects Working Team (now Fire Use Working Team) also identified barriers to prescribed burning. The most frequently reported obstacles included a shortage of qualified people, need for public education, limited burning windows, high hazards in the Wildland Urban Interface, lack of funding, extreme fire behavior, and politics. These results could also apply to the go/no go decision on WFU.

Cleaves et al. (2000) conducted a mail survey of 114 USFS Fire Management Officers (FMO) in seven USFS regions (all except Alaska). Their survey aimed to assess influences on prescribed burning activity and costs, and as a result identified barriers to prescribed burning. The 95 FMOs who responded indicated that smoke and air quality, a lack of funding for prescribed burning, personnel shortages, narrow burning windows, and liability inhibited prescribed burning activity. Although the Cleaves et al. (2000) study did not specifically address WFU, the results support factors suggested anecdotally and discussed previously.

Miller and Landres (2004) conducted the only study specifically examining influences on WFU. Their research included both a mail survey and a workshop. The mail survey targeted 300 fire and fuels managers with the USFS, the National Park Service, Bureau of Land Management, Fish and Wildlife Service, and the Bureau of Indian Affairs. The

results of their questionnaire indicated that firefighter safety, potential impacts to private property, developments and facilities, and threats to human life in the Wildland-Urban Interface constituted the primary reasons to suppress candidate WFU events. Miller and Landres' survey also revealed the primary reasons to allow WFU: to allow natural processes, to improve wildlife habitat, to reduce fuel hazards, and to improve resource conditions.

The workshop conducted as part of Miller and Landres (2004) study determined several additional obstacles to managing wildland fires for resource benefits. The 14 workshop attendees (fire managers and fire ecologists) indicated that multiple ignitions, a lack of available resources, administrative boundaries, conflicts with other resource management objectives, and potential impacts to the Wildland Urban Interface inhibited the decision to allow WFU. Participants also suggested that the decision-maker's risk-posture could constrain the decision to "go."

1.2.2. *Impetus for this study*

A review of the literature on the factors influencing an agency administrator's decision to authorize wildland fire use indicates an information gap. Beyond items mandated by policy to be included in the decision, several authors have addressed this question in passing (e.g., Benedict et al. 1991, Czech 1996, Daniels 1991). The four formal studies discussed previously have examined influences on prescribed burning, factors affecting fire managers' risk-behavior, and barriers to using WFU as identified by fire and fuels managers (Cleaves et al. 2000, Cortner et al. 1990, Miller and Landres 2004, NWCG

1995b). Although the elements found in these studies probably find their way into the go/no go decision, no research has specifically solicited the administrators' input as to their relative importance, if any.

Opting to 'go' predicates the viability of WFU as a fuel management tool. Understanding the drivers of the 'go' decision requires identifying the factors affecting the people who must assume authority for the consequences. The literature review indicates a gap in the knowledge that this investigation seeks to fill. Specifically, this study aims to determine the factors influencing the USFS line officers' go/no decision.

2. METHODS

This study surveyed USFS district rangers with wildland fire use authority on their districts in USFS Regions 1, 3, and 4. The following section describes the population studied, the survey instrument used, the interview process, and subsequent data analyses, in addition to the possible errors associated with data collection.

2.1. Potential Population

The research question addressed in this study immediately narrowed the potential population to those agency administrators who could authorize wildland fire use in their areas. Although all federal land management agencies (U.S. Department of Agriculture Forest Service, U.S. Department of the Interior Bureau of Land Management, National Park Service, Fish and Wildlife Service, and Bureau of Indian Affairs) have provisions for wildland fire use, interviewing managers in five agencies would prove prohibitively expensive. As an agency with a mandate to manage for multiple use, the USFS presented

an ideal candidate for examining the decision making behind wildland fire use. To further restrict the scope of this study, I elected to highlight USFS district rangers with wildland fire use authority on their districts in USFS Regions 1, 4, and 3. These regions represent a swath through the Intermountain west.

Although these regions include North Dakota, South Dakota, and Nevada, National Forest System (NFS) lands in these states do not have provisions for wildland fire use. The population therefore included district rangers on National Forests in Montana, Idaho, Wyoming, Utah, Arizona, and New Mexico. While the management of NFS lands falls along regional boundaries, fire management follows boundaries determined by National Interagency Coordination Center (NICC) geographic areas. These coordination centers orchestrate response to wildland fires in areas that roughly correspond to the USFS regions. The areas included in this study correspond to three Geographic Area Coordination Centers (GACC): Northern Rockies, Eastern Great Basin, and Southwest.

2.1.1. Identifying the population

This study narrowed its scope short of including all USFS district rangers with wildland fire use authority due to time and budget constraints. A combination of physical and confidentiality factors indicated that USFS Regions 1, 3, and 4 would provide a coherent yet manageable population to investigate.

Lightning constitutes the primary ignition source for wildland fires (Agee 1993). Although areas in the eastern U.S. typically receive more cloud-to-ground lightning

strikes than the West does (NOAA 2004), significant rainfall typically accompanies eastern lightning storms. In contrast, western thunderstorms often lack moisture sufficient to extinguish ignitions resulting from lightning activity. Whereas the Eastern and Southern GACC areas averaged 661 lightning fires per year between 2001 and 2004, the intermountain west coordination centers[3] averaged 1596 ignitions per year, the Northwestern GACC averaged 1962 lightning fires per year, and the California GACCs[4] averaged 511 per year (NICC 2002, 2003, 2004, 2005). Since, by definition, only lightning fires have the management option of wildland fire use it seemed logical to exclude ranger districts in the wetter eastern and southeastern regions, as well as the less lightning fire-prone California (Region 5).

The occurrence of lightning fires would indicate that district rangers in the Northwestern and Rocky Mountain GACC areas, corresponding to USFS Regions 2 and 6, also belonged to the population of interest. However, too few rangers in these regions have wildland fire use authority on their districts to permit confidentiality in their responses (nine in Region 2 and seven in Region 6).

The regions that meet the eligibility criteria follow the Rocky Mountain spine south from Montana. They lie inland, in the dry areas characterized by orographic precipitation events in the summers and usually reliable snowfall in the winters. Monsoonal flow tends to bring additional summer rains to Arizona, New Mexico, and southern Utah. Aside from the lightning trends that set them apart, Regions 1, 3, and 4 exhibit a broad

[3] Northern Rockies, Eastern and Western Great Basin, Rocky Mountain, and Southwestern

range of historical fire frequencies, fire regime condition classes, and demographic distributions that exemplify the land management challenges apparent in other USFS regions.

Regions 1, 3, and 4 encompass all five fire regimes, although predominantly fire regimes I, II, and III, with few areas in regimes IV, and V (Hardy et al. 2001, Schmidt et al. 2002). Areas of fire regime V fall mostly within the portion of Wyoming included in Region 4 (Schmidt et al. 2002).

Regions 1, 3, and 4 include NFS lands in all three FRCC categories. Areas which have not missed any fire return intervals (FRCC 1) include some of eastern Montana, most of Utah and western Wyoming, as well as southern Arizona (Schmidt et al. 2002). Lands in the northern half of Arizona, most of New Mexico and a smattering through Idaho have skipped one or more fire return intervals (FRCC 2, Schmidt et al. 2002). Northwest Montana, the Idaho panhandle, and some areas in north central Arizona have missed multiple fire return intervals (FRCC 3, Schmidt et al. 2002).

In addition to covering a range of biological characteristics, the three regions in the population also span a variety of demographic attributes. Although small rural communities dot the landscape throughout the Intermountain west, several major urban areas also fall within the study area. Salt Lake and Utah counties in Utah have a combined population of 1.32 million people. Over 3.89 million people live in Maricopa

[4] Northern Operations, and Southern Operations

county, Arizona. Bernalillo and Santa Fe counties, New Mexico, account for 0.72 million residents (U.S. Census Bureau 2005).

Beyond the presence of metropolitan areas within USFS Regions 1, 3, and 4, an increasing number of residents occupy the wildland-urban interface (WUI). Defined as the combination of areas with houses next to contiguous vegetation and areas where houses and vegetation intermingle (Stewart et al. 2005), the WUI grew by an average of about 30 percent (median of 31 percent) between 1990 and 2000 (Stewart et al. 2005).

2.1.2. Identifying individual respondents

Unpublished data provided by the USFS Rocky Mountain Research Station Aldo Leopold Wilderness Research Institute (ALWRI) helped identify individual respondents within USFS Regions 1, 3, and 4. This database included the acreage approved for WFU in each USFS wilderness area and summarized this information by forest.

I cross-referenced this database with a list of the districts that manage each wilderness area. Wilderness.net, a website maintained by ALWRI, contained the information necessary to construct a list of districts with areas approved for WFU. Where data on this website were incomplete, phone calls to forest offices fleshed out the list of districts.

The original list of district rangers did not include those without wilderness areas but with WFU as a management option on non-wilderness lands. The Region 3 Director for Fuels and Ecosystem Management suggested three additional district rangers with WFU-

authority outside of wilderness, and one district ranger in Region 1 also indicated one additional ranger in a similar position. The USFS employee directory, also available on the internet, provided names, email addresses, and phone numbers of district rangers.

This identification process led to an initial population of 81 district rangers with WFU authority both in and out of designated wilderness across Regions 1, 3, and 4. Twenty-nine rangers work in Region 1, 27 in Region 3, and 25 in Region 4. Given the small population size, I conducted a census rather than a sample of the identified district rangers.

2.2. Survey instrument

I developed the survey instrument in December 2004 and January 2005. Questionnaire construction followed widely accepted guidelines (Groves et al. 2004, Sudman and Bradburn 1982) and is detailed in this section. This study relied on a telephone questionnaire because of the associated improvements in response rate and efficiency over a mailed one (Dillman 1978, Groves et al. 2004). Time and budget constraints prohibited face-to-face interviews.

2.2.1. Scoping

The literature review detailed previously indicated four surveys that could provide direction (Cleaves et al. 2000, Cortner et al. 1990, NWCG 1995, Miller and Landres 2004). However, all four relied either on having respondents rank lists of factors or on reacting to scenarios. Both ranking and scenarios usually provide a prohibitive cognitive

load to telephone respondents, so this study did not include any previously administered questions.

The results from these previous surveys did help in identifying the potential influences on the go/no go decision to investigate in this study. In addition to this earlier research, scoping conversations with one current district ranger, one deputy forest supervisor (former district ranger), and one assistant fire management officer (AFMO) further honed the focus of the information needs. I included the AFMO in this exploratory phase to get an outside perspective on the factors potentially influencing the go/no go decision.

2.2.2. Pre-tests and content verification

Most questions addressed the district rangers' behaviors with respect to authorizing WFU, attitudes towards the wildland fire use program, their beliefs about the relative influence of factors such as external conditions, public perception, budgets, and protocol (questions 1-18, 23, 24, 29-38, 41-45). Question formulation followed guidelines outlined by Groves et al. (2004). The questionnaire did include several sensitive questions probing the district rangers' past experience with fire, their relationship with their staff, beliefs about potential career impacts following a converted WFU, and demographic attributes (questions 19-22, 25-28, 39, 40, 46-56). Wording for these questions followed the suggestions outlined by Sudman and Bradburn (1982) as modified by Groves et al. (2004).

One forest supervisor, one deputy forest supervisor, and one acting district ranger pre-tested the questionnaire in January of 2005. The pre-testing procedure involved a hybrid of concurrent think-aloud interviewing (Tourangeau et al. 2000) and probing for unaddressed influences. This process refined wording and verified that the respondents understood the questions as intended.

After pre-testing, the questionnaire was reviewed by one additional district ranger, one AFMO, one fire use manager trainee, the Region 1 Director for Watershed, Wildlife, Fisheries, and Rare Plants, and two fire ecologists at the Aldo Leopold Wilderness Research Institute. Appendix A contains the final version of the questionnaire, as administered in this study.

2.3. Implementation

2.3.1. Contacts

I initially contacted regional-level fire staff. The Region 1 Assistant Director for Fire Management, the Region 3 Director for Fuels and Ecosystem Management, and the Region 4 Deputy Director for Fire, Aviation, and Air Management offered to write cover emails introducing my study topic. I followed this introduction with an email to the district rangers requesting an appointment. Those rangers who still did not respond received one additional email, which further explained the research project's purpose and requested an explanation if they preferred not to participate. Eighteen of 81 interviewees failed to reply after the second email. I resorted to calling these 18 to set up the interview appointment. In the few cases where this first phone call merely resulted in leaving a

message, I called a second time and again left a message if I reached voice mail or a secretary. This four-attempt method resulted in an 88.9 percent contact rate (72 of 81).

Both email and phone contact revealed that 22 district rangers did not have the ability to use WFU. I did not attempt to collect data from these individuals because the questionnaire targeted those with the latitude to make the go/no go decision.

2.3.2. Interviews

Initial contact with the district rangers in the study population occurred on February 1, 2005. I conducted the first telephone interview on February 9, 2005. The majority of the questionnaires were administered by March 4, 2005, with the final interview held on March 21, 2005. One district ranger did not have signing authority on the Wildland Fire Implementation Plan Stage 1 documentation; so the go/no go decision on that district went to the next higher administrative unit, the national forest. An interview with the forest supervisor in this instance supplanted one with the intended respondent. The district rangers spent an average of 27.5 minutes (median of 24) answering the survey questions.

2.3.3. Final case disposition

The American Association for Public Opinion Research (AAPOR) defines several different categories to describe the final case disposition for surveys (AAPOR 2004).

District rangers whom I did not contact after the second message but who did have WFU on their districts fall into the 'confirmed eligible, message left' category (2.221). I have

included those rangers whom I was unable to contact or confirm eligible into the 'unknown if housing unit' (3.1) category, since the housing unit comprises the main eligibility criterion described in the AAPOR standard definitions. In two cases I made contact with the district ranger but scheduled an appointment that they did not keep. I assigned these the code 2.35, as eligible, 'non-interview for miscellaneous other reasons'. Contact with 22 district rangers revealed that they did not have WFU authority on their districts. These individuals fall into the 'not eligible' category, represented by case code 4.1. Table 1, below, summarizes the final case codes and the code class used to compute response rate.

Table 1: Final case disposition

Description	Number	Final case code	Code class
Interview completed	50	1.1	I
Eligible, non-contact	3	2.221	NC
Unknown eligibility, non-contact	4	3.1	UH
Eligible, non-interview (appointment not kept, not rescheduled)	2	2.35	O
Not eligible	22	4.1	

The AAPOR defines six methods of obtaining response rate, ranging from conservative to expansive. These techniques for determining the ratio of complete interviews to number eligible reporting units vary based on consideration of partial interviews and cases of unknown eligibility. Using the most conservative computation yields a minimum response rate (RR1) of 84.75 percent. Twenty-two district rangers from Region 1, 12 from Region 3, and 17 from Region 4 participated.

2.4. Error associated with this study

Two types of error can mar survey results: non-observation and observational. The former type of error stems from excluding part of the population of interest in measurement. Observational errors stem from inaccuracy in the measurement itself (Groves 1989).

As a census with an 84.75 percent response rate, errors of non-observation cause minimal concern. Conducting a census eliminates concerns of sampling errors. Although not eradicated, error associated with coverage and non-response was minimized.

Non-respondents can cast a shadow on result validity if their answers differ significantly from those of the rest of the population. Of seven non-respondents, four corresponded to either vacant positions or positions that had been filled since the 2004 fire season. The remaining three non-respondents face the same terrain, weather, fuel, and political contexts as their neighbors who participated. This similarity in geographical and political situations suggests that their responses would resemble their neighbors' and would therefore not alter the study's results.

The steps taken in developing the questionnaire sought to mitigate any observational errors. Such misrepresentations result from the interviewer, the instrument, the respondent, or the mode of collecting responses (Groves 1989). As the sole interviewer and principal person concerned with result validity, I minimized the influence of multiple interviewers, misreading questions, and incorrectly recording answers. The cognitive

interviewing verified that the respondents understood the questions' language as intended. This pre-testing procedure also minimized question order effects.

A combination of residual instrument errors and respondent errors may have contributed the most significant source of error in the data collected. Several of the questions reflected areas of Agency direction and professional motivations. Despite confidentiality guarantees, the respondents could have opted to 'toe the Agency line' in their answers and thus not provide completely candid answers. During the interviews, the district rangers were encouraged to expand on any of their responses. This led to 47 unprompted discussions that added detail to the respondent's answers. The district rangers were also encouraged to request any clarification they needed to mitigate any negative effects of phone interviewing.

2.5. Analysis

As the main survey to date of line officer attitudes and beliefs towards WFU, statistics describing the population deserve attention. As a census of the population of district rangers with WFU authority in USFS Regions 1, 3, and 4, their responses do not require tests of statistical significance. In addition to these summary statistics, I chose to conduct Classification and Regression Tree (CART) analysis. This study used the Statistical Package for the Social Sciences (version 10.0) and CART5.0 (Salford Systems) to conduct the analyses.

CART analysis presents several advantages over parametric models. The classification analysis does not rest on assumptions about the distribution of predictor variables' error terms (Steinberg and Colla 1997). Whereas regression analysis requires the user to identify interactions between variables prior to analysis, CART can handle interactions between independent variables. The graphical tree output facilitates model interpretation and classification of new cases. CART analysis's predictive abilities compare to other regression models (Breiman et al. 1984, Lewis 2000). Appendix B contains a description of how CART functions.

Analysis included two CART models. In both, the binary dependent variable identified whether the district ranger had authorized WFU (1) or not (0). The first model used the full data set resulting from the questionnaire responses. The second used a reduced group of factors to classify the district rangers as having authorized WFU on their unit. The rationale behind the data reduction follows.

2.5.1. Data reduction

The literature review and the questionnaire scoping process led to the creation of eight variables to use in the CART analysis. These independent variables include confidence in staff, external factors, experience with fire, agency support, protocol, perceived program value, staffing level and public perception. Definitions of these variables follow.

- Confidence in staff (STFTRST). This variable captures both the amount of communication there is on the district about the WFU program, how much trust the

ranger has in the Fire Management Officer's recommendations and how much they trust the fire use managers.

- External factors (EXT). This variable reflects the extent to which other activities, weather, time of year, location, preparedness level, fire danger indices, presence of ignitions, and ability to use WFU out of wilderness affects their decision. EXT does not include resource availability or funding levels.
- Past experience with fires (FIRE). This variable indicates the respondent's experience with fire. It includes total number of type 1 or 2 fires on their unit in the last three fire seasons as a fraction of the maximum number of T1/T2 fires reported, if they have had any escaped prescribed fires or WFU fires, their level of fire line qualifications and whether or not they have had any fire ecology classes. FIRE does not include acreage of most recent T1/T2 fire since the frequency of complex fire events is expected to have more influence on the decision-makers.
- Agency support (AGSPRT). This variable approximates the perceived amount of support from the agency, potential for career impacts and agency-provided incentives for WFU. This variable also includes attitudes towards funding levels. Answers to component variables that reflect a perceived lack of support from the agency are attributed a negative sign.
- Staffing (STAFFLVL). This variable captures concerns for resource availability, and recruitment and retention of qualified people to manage WFU events.
- Public perception (PUBPERC). This variable reflects the respondent's consideration for public support for WFU, desire for public education and support, and concern for impacts to private land.

- Protocol/process (PRTCL). This variable indicates the extent to which respondents believe protocol facilitates the go/no go decision.
- Perception of program validity (PROGVAL). This variable reflects the district rangers' attitudes towards returning fire to the landscape and the use of WFU as both a fuel management and a wilderness management tool. PROGVAL also includes their belief in the ability to manage non-suppression fires to meet their objectives, the cost-effectiveness of WFU as a fuel treatment, and land stewardship incentives to use WFU.

All variables vary positively, with higher scores indicating higher levels of the variable in question. Ordinal questions are adjusted to a 0 to 1 scale. Responses to the post-coded open-ended questions that capture the factor in question are assigned a value of 1. For example, for the staffing level variable, STAFFLVL, three responses to question 24, "what do you think you need to make it possible to manage a non-suppression fire to meet your objectives," reflected the need for adequate staffing. Each instance of these responses was given a score of 1. A respondent answering that they needed both resource availability and funding for quality people/resources, for example, would receive a score of 2. These scores were not re-scaled to fit the 0-1 range reflected in the other component variables because I determined that volunteered responses carry more weight than ones fit to a predetermined scale. Collapsed variable values were assigned by summing the component variable scores. Appendix A contains the questionnaire response code key and Appendix C contains a detailed key for the collapsed variables' components.

3. RESULTS

This section presents the results of the interviews of district rangers in USFS Regions 1, 3, and 4. Descriptive statistics will be presented first, followed by the results of the Classification and Regression Tree (CART) analysis.

3.1. Descriptive Statistics

This section follows the question grouping established in the survey instrument and presents highlights from these groups. Most questions offered a four-point response scale:

0: not at all

1: to a small extent

2: to some extent

3: to a very great extent.

As few regional differences surfaced between the respondents' answers, these variations will be reported only for the applicable questions. Responses to the four open-ended questions follow the summaries for the main question groups. Appendix D contains the full results, summarized by USFS region.

3.1.1. Demographics

The population interviewed in this study had been with the USFS for an average of 24 years (median: 25), and had been in their current position for slightly longer than 5.5 years on average (median: 4). Approximately half had line officer experience prior to their current positions, and 60 percent reported their career goal as district-level

management. Almost half (48 percent) worked as resource specialists (range specialists, wildlife or fish biologists, ecologists) and 42 percent moved into line officer duty from the timber program. Seventy-eight percent of the respondents were male and 72 percent of the respondents identified themselves as risk-takers.

3.1.2. Eligibility

This set of three questions aimed to identify whether or not the respondent had had the opportunity to make the go/no go decision in the past three fire seasons (1), if they had elected to authorize WFU (2) and if they had the authority to use WFU outside of designated Wilderness (3).

- 80 percent authorized at least one lightning strike to be managed as WFU (N=46);
- 66 percent have WFU authorization outside of designated Wilderness currently or in Forest Plan revisions (N=50);
    - 82 percent of those with the ability to use WFU outside of designated Wilderness work in Regions 3 and 4 (N=33).

3.1.3. Program validity

This set of three questions (4-6) intended to determine the respondents' attitudes towards the goal of returning fire to the landscape and the effectiveness of WFU at accomplishing that goal.

- 90 percent believe that restoring fire to the landscape is "very important" as a land management goal (N=50 unless otherwise noted);

- 60 percent determined that WFU is an effective tool for returning fire to the landscape to a "very great extent";
    - 92 percent of Region 3 respondents identified WFU as effective to a "very great extent" (N=12);
- 42 percent reported that WFU meets their wilderness management objectives to a "very great extent".

3.1.4. External factors

Questions 7-15 addressed the influence of external factors not specifically addressed in the WFIP1 process.

- 28 percent reported having high-priority, non-fire projects that affected their go/no go decision;
- 67 percent indicated that time of year influenced their go/no decision to a "very great extent" (N=46);
- 46 percent said that an ignition's proximity to the WFU-approved area's boundary affected their decision to a "very great extent" (N=46).

The three final questions in this series addressed the weight accorded to public support and public perception.

- 50 percent indicated that concern for public support factored into the go/no go decision to "some extent" (N=46);
- 48 percent reported that public perception of air quality entered into their decision to "some extent" (N=46);

- 48 percent considered public perception of risk from the fire escaping to "some extent" in their go/no go decision (N=46).

3.1.5. Fire experience

These questions (16-24, 47, 48) explored the respondents' experiences as line officers with suppression, prescribed, and fire-use fires.

- 68 percent reported being the line officer for either a Type 1 or Type 2 suppression fire;
- 18 percent had a prescribed fire on their unit escape;
    - Prescribed fires escaped due to fire behavior (44 percent) and weather (33 percent) (N=9);
- 20 percent had authorized a WFU event that was converted to a suppression fire (N=46);
    - 44 percent reported that Maximum Manageable Area restrictions motivated the conversion to suppression (N=9);
- 54 percent thought that it was possible to manage a non-suppression fire to meet their objectives to a "very great extent".

The final question in this section asked respondents to identify what they needed to manage a non-suppression fire to meet their objectives. Resource availability (28 percent), fire danger indices (14 percent), public support (12 percent), and quality people (12 percent) surfaced most frequently.

3.1.6. District communication and confidence in staff

Questions 25-28 addressed the amount of pre-season communication about WFU and the level of confidence in their staff reported by the respondents.

- 26 percent reported that their staff was involved in at least one annual training event focusing on managing a WFU event;
- 66 percent felt that they shared similar attitudes about an appropriate go/no go decision with their Fire Management Officer "most of the time";
- 68 percent thought to a "very great extent" that their local WFU managers would make appropriate tactical decisions for a WFU event in their area;
- 60 percent thought to a "very great extent" that national Fire Use Management Teams would make appropriate tactical decisions for a WFU event in their area.

3.1.7. Forest Service policy and protocol

The first five questions in this series (29-33) examined funding for WFU and fuels management performance targets.

- 43 percent indicated that using the 'G' code to pay for WFU does nothing to help them meet their district's fuels target (N=40);
- 40 percent thought to a "very great extent" that WFU was a cost-effective way to achieve fuels targets.

The remaining questions (34-45) probed the extent to which current decision protocol facilitates the go/no go decision and explored the incentives and disincentives to authorizing WFU.

- 48 percent indicated that, to "some extent," their Fire Management Plans contained useable information for the go/no go decision;
- 50percent reported that the Wildland Fire Implementation Plan Stage 1 process aided the go/no go decision to "some extent";
- 50 percent felt that they had access to the resources they needed to manage a fire as WFU to "some extent";
- 48 percent revealed that, in their opinion, authorizing a WFU that damaged other values at risk would have a negative impact on their job;
- 90 percent said they had incentives to use WFU;
- 64 percent reported that they had disincentives to use WFU.

Open-ended questions asked respondents to identify any incentives (42), or disincentives (44) to authorize WFU and to rate the top three factors affecting their decision (45). The number of responses follows each response in parentheses. As respondents could provide more than one answer, the total number of responses exceeds the number of respondents. These open-ended questions were post-coded. The total number of answer categories resulting from the post-coding process follows the response summary for each question.

- Ecology/land stewardship (41) was reported most often as the incentive to authorize WFU (15 answer categories);
- Risk of the unknown (8), career impacts (7), and public perception (7) surfaced most frequently as disincentives to WFU (22 answer categories);

- Fire danger indices (21), resource availability (20), location (17), and time of year (16) were identified as the top factors influencing the go/no go decision (26 answer categories).

3.2. Classification and Regression Tree Analysis

Classification and regression tree analysis (CART) offered the most appropriate analysis tool for this data set. The go/no go decision amounts to a detailed risk assessment that weighs potential costs against potential resource benefits. The Decision Criteria Checklist, described previously, specifies five tiers to this process:

- threat to life, property, or public and firefighter safety;
- effects on natural and cultural resources;
- relative risk indicators;
- other proximate fire activity;
- other agency administrator issues.

If, at any of these levels, cost exceeds benefit then the decision tips to 'no go' and the risk assessment stops. Other factors entering into the go/no go decision that this study explored could follow a similar tiered pattern. CART provides a sort of 'road map' to navigate such a hierarchical decision process. The classification marks each intersection and determines whether a case progresses towards 'go' or if the risk assessment halts. Appendix B contains a detailed description of the CART technique.

3.2.1. Classifying influences on the go/no go decision

Two separate CART analyses were run on the survey data collected during this study. The two model runs used a binary target variable, WFU. The binary variable resulted

from collapsing the number of lightning strikes in the WFU-approved area managed as WFU in the last three seasons. A score of 0 was attributed to answers of 'none' or 'few.' 'About half,' 'most' or 'all' were attributed a score of 1. Model runs used Salford Systems CART 5.0 software (Steinberg and Colla 1997) and kept the default settings of the Gini splitting criterion, 10-fold cross-validation, minimum parent node N=10, and minimum child node N=1. The best tree was selected based on minimum probability of misclassification estimated through cross-validation.

The first model included all the interval, ordinal, and binary variables used in the survey instrument (Model 1). The second model relied on the aggregated variables developed as described in the Methods section. Model 2 included the eight aggregated variables – program value, external factors, fire experience, agency support, protocol, staffing level, and public perception.

The summary of these models' classification and performance follows. Cross-validation (test) prediction success provides the most accurate estimate of model performance (Steinberg and Colla 1997), and is reported for both models.

Model 1

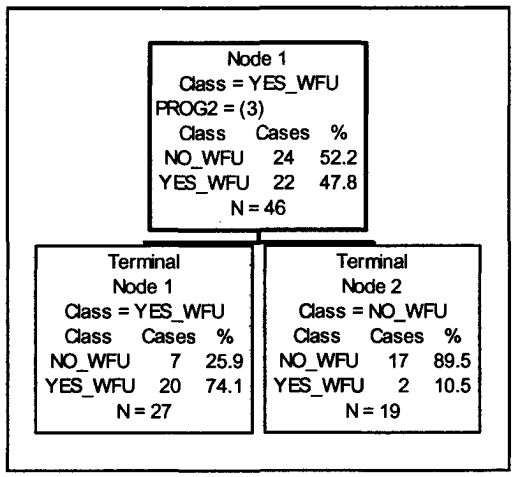
Model 1, run using the raw data set from the interviews, identified one primary splitter. The response to question 5, "to what extent is WFU an effective tool for returning fire to the landscape", allowed the cleanest partition between those respondents who authorized

WFU and those who did not. Table 2, below, summarizes Model 1 performance, and Figure 1 illustrates the model.

Table 2: Model 1 test prediction success

				Predicted Class	
	Actual Class	**Total Cases**	**Percent Correct**	**0 N=19**	**1 N=27**
Test data	0	24	70.8	17	7
	1	22	90.9	2	20

Figure 1: CART Model 1



In this model, all respondents who answered "to a very great extent" (coded 3) to PROG2 (question 5) fall into the left branch (terminal node 1). This split isolates 20 of 22 respondents (91%) who authorized WFU. Respondents who do not meet the splitting rule fall into the right branch (terminal node 2), which isolates 17 of 24 respondents who did not authorize WFU.

This tree offers insight into the influences on the go/no go decision. Looking at surrogate splitters provides additional information on factors affecting the decision without sacrificing accuracy. These surrogate splitters are selected based on their ability to mimic the patterns in the primary splitting variable (PROG2). Respondents who follow the splitting rule for the surrogate splitter have similar characteristics to those who follow the splitting rule for the primary splitter. Table 3, below, summarizes the surrogate splitters for node 1.

Respondents identifying themselves as either risk-takers (coded 3) or as risk-neutral (coded 1) in DEM1 (question 46), and respondents with fewer than 22.5 years with the USFS (question 50, DEM5) behave similarly to respondents who believe that WFU is effective at returning fire to the landscape to a "very great extent." These respondents would fall into the left branch illustrated in Figure 1 and are likely to authorize WFU.

Table 3: Model 1 surrogate splitters, node 1

	Surrogate	Split	Association	Improvement
1	DEM1	1,3	0.265	0.042
2	DEM5	22.5	0.232	0.061

Model 2

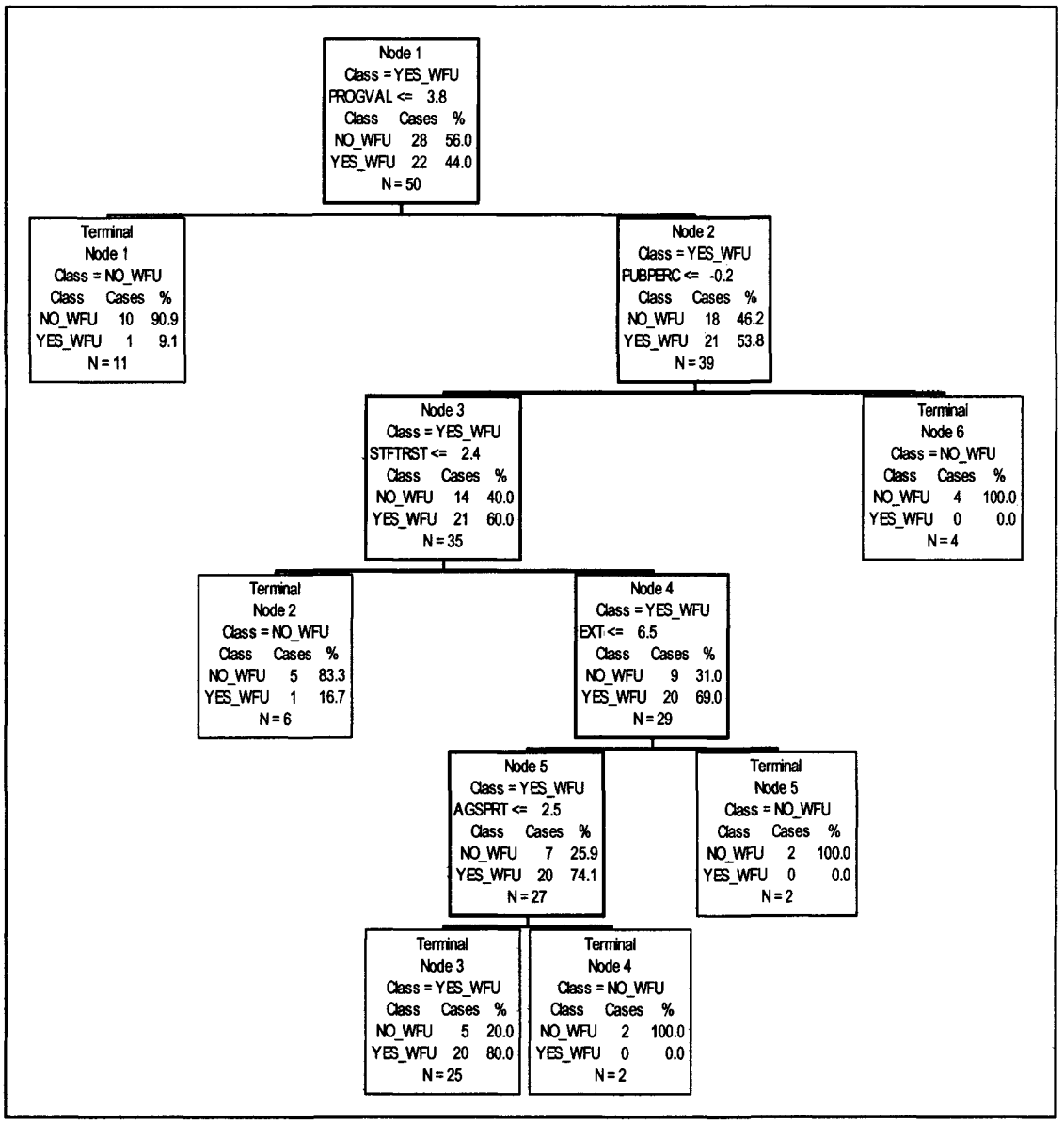
Model 2 used eight collapsed variables to classify the dependent variable. This classification resulted in a tree with five decision nodes and six terminal nodes. Program value, public perception, staff trust, external factors, and agency support successfully identified 63.6% of respondents who authorized wildland fire use. Table 4, below, summarizes Model 2 performance.

Table 4: Model 2 test prediction success

				Predicted Class	
	Actual Class	**Total Cases**	**Percent Correct**	**0 N=19**	**1 N=27**
Test data	0	28	67.9	19	9
	1	22	63.6	8	14

Figure 2, on the following page, depicts Model 2. This model presents a more complex map to navigate than Model 1. Each intersection, or node, provides a make-or-break rule for whether or not the respondent will continue down the tree.

Figure 2: CART Model 2



The first intersection, at program value (PROGVAL <= 3.8), diverts 11 respondents and classifies them as not authorizing WFU (terminal node 1). This indicates that program value is the most important factor, and progression to the next decision rules hinges on the score for this variable.

Respondents who make it through the intersection at program value move to the next one, at public perception (PUBPERC <=-0.2). Here, though counter-intuitive, respondents who perceived a level of public support above –0.2 are classified as not authorizing WFU (terminal node 6). Survey participants who reported a level of public support below this threshold value continue to the next intersection, which occurs at staff trust.

This more intuitive split indicates that staff trust plays the next most important role in determining whether or not respondents have authorized WFU. Respondents who reported a level of confidence in their staff below 2.4 are classified as not authorizing WFU (terminal node 2) and do not continue down the tree.

The next criterion involves external factors. Respondents who scored at the upper end of external considerations (EXT>6.5) do not authorize WFU (terminal node 5). Those who meet the splitting rule of EXT <= 6.5 move on to the final intersection, at agency support.

This final tier separates those respondents who perceive that the Agency facilitates the decision to use WFU. Again counter-intuitively, respondents who scored above the threshold value of 2.5 did not authorize WFU (terminal node 4). Conversely, respondents who met the decision rule AGSPRT<=2.5 did authorize WFU (terminal node 3). Ninety-one percent (20 of 22) of respondents who authorized WFU follow the tree all the way through to this final intersection.

4. DISCUSSION

Interpretation of CART-analysis results indicates that the go/no go decision rests on personal commitment to returning fire to the landscape. This overarching theme helps explain the sometimes counter-intuitive modeling results. The decision structure presented by Model 2 highlights potential deterrents to WFU, and responses to individual survey questions suggest specific barriers to WFU. These potential barriers lead to recommendations for facilitating the incorporation of WFU into the fuel management toolbox.

4.1. "You are acting outside the scope of your employment if you do not do what is best for the land"

Both CART models indicate that the value placed on the WFU program provides the most important determinant of whether a respondent authorized wildland fire use.

In Model 1, the extent to which the respondent thinks the WFU program is effective at returning fire to the landscape provides the sole split. The surrogate splitters indicate that those who find WFU effective to a "very great extent" are either risk-takers or risk-neutral, and have been with the USFS for fewer than 22.5 years. This model suggests that for those line officers who emphasize returning fire to the landscape, the benefits of letting a natural process occur outweigh the effects of other factors. The emphasis on the value of the program helps explain why respondents who have not been with the USFS as long are more likely to authorize WFU. As one respondent suggested, a "dominant suppression paradigm" still permeates the USFS. Changes in fire policy show a shift from suppression to fire management at the national level. However, land managers

perhaps steeped in earlier organizational values have some reservations about WFU as an effective tool, even if the broader goal of returning fire to the landscape resonates with them.

The tree presented in Model 2 mirrors the findings of Model 1 and fleshes out the hierarchy in the decision process. From Model 2 emerges a group of decision-makers that stands behind returning fire to the landscape, and is strongly motivated by 'doing the right thing' for the land. Beyond this belief, these district rangers have confidence in their staff but do not feel supported by either the public or their employer. As one respondent said, "the nexus of temporal, spatial, and political factors doesn't always align" and yet individuals driven by their desire to do right by the land will proceed with WFU.

Combining the results of Models 1 and 2 suggests that a cohort of district rangers is motivated by "the laudable, noble goal of ecosystem restoration" and is convinced that WFU will accomplish this goal. According to the CART models, this cohort will predictably see potential benefits to the resource outweighing potential risks, and decide to 'go.' The models suggest the idealistic nature of those who reliably authorize WFU, but also highlight the obstacles that prevent district rangers from authorizing WFU across the board.

4.2. "There is more value to the resources at risk than value to allowing fire back on the landscape"

Responses to the open-ended questions in this study draw attention to the risks that make implementing a stewardship ethic a costly gamble. External factors, public perception, resource availability, and agency support all surfaced as top considerations that inhibited the 'go' decision.

4.2.1. External factors: "WFU is risky business"

Environmental factors came up as the main consideration influencing the go/no go decision, and a key to managing non-suppression fires to meet objectives. Specifically, fire danger indices were mentioned seven times in the context of managing a non-suppression fire and 21 times as the top consideration in the go/no go decision. Location and time of year surfaced 17 and 16 times, respectively, as the most important factors influencing the go/no go decision. Beyond these repeated concerns, weather, ignitions, smoke, and threatened and endangered species habitat all came up as considerations that weighed in the go/no go decision. These factors reflect concern for "risk of the unknown" that 8 respondents mentioned as a disincentive to use WFU.

Deciding to authorize a WFU event can engage a district's management capacity for an extended period. The time commitment involved depends on unpredictable events such as weather and lightning ignitions. In the midst of this uncertainty, air quality and endangered species regulations, and private property considerations impose definite

restrictions on management activity. Even for those supportive of fire restoration, the daunting requirements to ensure in this uncertain environment often prove prohibitive.

4.2.2. Public perception: "Dick Cheney is not too hip on smoke"

Public support and public perception surfaced six times as a requirement for managing non-suppression fires to meet objectives and seven times as a disincentive to using WFU. Respondents evoked concerns for the political fallout of the external considerations described previously. Smoke, perceived or real threats to threatened and endangered species habitat, and resource damage perceived as unacceptable by the public, all came up as specific areas of public concern. These concerns stem to some extent from a partially misinformed public that still views all wildland fires as a threat.

4.2.3. Resource availability: "We need trained people with the right qualifications"

Resource availability surfaced 20 times as the top factor entering into the go/no go decision, 14 times as what was needed to manage a non-suppression fire to meet objectives, and in 18 unprompted discussions that arose during the interviews. Respondents mentioned that the level of qualifications required for fire use managers constrained WFU authorization. In addition, several respondents indicated that they lacked skilled personnel in sufficient numbers to manage WFU.

Respondents also indicated that candidate lightning ignitions frequently occurred when other fire activity was high. In these situations, the line officers did not have the staff on hand to manage the ignitions as WFU. Potential staff shortages cause concern given the indeterminate duration of WFU events.

Respondents mentioned the need for aerial resources in addition to personnel. Two respondents specifically indicated that the availability of helicopters had allowed them to manage WFU events to meet their objectives. In both cases, water bucket drops by the helicopters cooled down flanks that would have otherwise hit management action-points and triggered a shift to suppression.

4.2.4. Agency support: "Signing 'go' is a lonely feeling"

The need for agency support surfaced as a requirement for managing non-suppression fires to meet objectives. Respondents also cited a perceived lack of agency support as a disincentive to authorizing WFU. This perceived lack of agency support takes two forms. First, respondents expressed a doubt that the agency would stand behind their decision if a WFU event went awry. Second, respondents indicated that the current focus on meeting hazardous fuel reduction targets impeded their use of WFU.

Potential career impacts surfaced seven times as a disincentive, and 14 times in unprompted discussions. Three respondents mentioned specific concerns about the potential for criminal charges as a result of recent after-action reviews of suppression fires that led to fatalities. Weighing resource benefits against potential damage to the decision-maker's family makes 'no go' more attractive.

Pressure to meet targets and lack of credit for WFU came up as disincentives to using WFU and surfaced in 14 unprompted discussions. These respondents indicated that they

could not credit acres restored through WFU towards fuels targets. At the same time, they suggested that prescribed burn targets conflicted with using WFU. Further, two respondents reported that they would suppress lightning fires within areas prepared for prescribed burns because the WFU fire would not count towards the prescribed fire targets.

4.3. Recommendations for facilitating 'go'

The CART models suggest that the line officers authorizing WFU do so because of their personal belief in the program, despite the risks involved. Responses to the open-ended questions indicate the inhibiting factors. If national policy dictates restoring natural processes as well as reducing fuel loads, then it is not sound to depend only on those altruistically driven to this goal to make the 'go' decision.

Expanding the use of wildland fire for resource benefits requires an effort to mitigate the inhibiting factors: external factors, public perception, resource availability, and agency support. The obstacles to using WFU need removal to encourage the 'go' decision. I propose eight recommendations to address these barriers. The first four recommendations involve steps that districts or forests could take to facilitate authorizing WFU. The next four suggestions require agency-wide effort.

4.3.1. District- or forest-level actions

1. Review implementation guidelines.

The implementation guidelines identify the conditions under which a 'go' decision is acceptable. These guidelines intend to facilitate the risk assessment included in the 'go/

no go' decision. If the prescriptions set in these guidelines set too stringent of conditions or do not assist the decision process, then the guidelines should be modified. In addition, Forest Plans currently under revision could expand the acreage eligible for WFU.

2. Preload information needs for WFIP 1.

External considerations such as weather, smoke production, and resources at risk provide challenges, if not limitations, to the use of WFU. With the compressed decision time frame, any steps taken ahead of time to identify and mitigate these concerns will reduce the perceived risk of the unknown. As one respondent noted, "WFU is a planning exercise." Pre-loading information on potential resources at risk, fuels, potential safety hazards, and natural fire breaks into a Geographic Information System, for example, would expedite the qualitative risk-assessment in the WFIP Stage 1.

3. Preplan WFIP Stage 3.

Similarly, the Stage 3 Wildland Fire Implementation Plan requires a detailed, quantitative risk assessment and cost estimates. These components constitute a considerable planning effort that could be conducted in the off-season. Once developed, periodic updates would ensure that the Stage 3 plans remained current. When the need arose, the predetermined quantitative risk assessment could guide the assessment for WFIP Stage 1. In addition, slight modifications would adapt the prepared Stage 3 plan to a specific WFU situation that progressed to that level.

4. Manage WFU through WFIP1 with local suppression resources.

Changes to the Wildland Fire Use Implementation Procedures Reference Guide in February 2005 modified the staffing requirements for WFU. With this iteration of the implementation guide, a Type 4 Incident Commander may manage a WFU through the Stage 1 level. These resources are more common at both the forest and district level than fully qualified Fire Use Managers. This new staffing requirement should ease some of the concerns for resource availability.

4.3.2. Agency-wide actions

1. Promote WFU to dispatch centers and geographic area coordination centers (GACC).

The availability of sufficient qualified personnel and the ability to use aerial resources can determine successful management of a WFU event. In some cases, having these resources available for even a few shifts maintained the fire in WFU status. Dispatch centers, part of forest-level fire staff, provide the link between fire-use managers and the resources they request, and the GACC establish resource priorities. Depending on other fire activity, successfully acquiring the needed resources depends on pursuing the resources more doggedly than necessary for a suppression fire. Promoting wildland fire use applications to the dispatch and GACC components of the fire organization may help WFU managers obtain the resources they need.

2. Clarify after-action reviews.

Concerns for career impacts seemed to stem largely from actions taken after recent reviews of suppression fires that led to fatalities and escaped prescribed fires. The survey results show that few district rangers visit the Wildland Fire Lessons Learned Center website, the main vehicle for sharing information on fire reviews. The Agency grapevine could have disseminated mis-information about the conditions under which the reviews occurred. In addition, one respondent indicated that After Action Review (AAR) teams were not consistent in their findings, and different teams arrived at different conclusions on similar cases. This inconsistency, in addition to a lack of accurate information, may lead to concerns over career impacts. Homogenizing the approach to AARs and ensuring accurate information sharing would alleviate career concerns.

3. Clarify goal of fuel reduction targets.

The USFS has stated two fire/fuel-related goals: 1) restoring fire as a natural process, and 2) reducing hazardous fuel loads. Results of this study indicate that district rangers feel pressure to achieve fuel reduction targets. Concurrently, line officers do not get credit for assuming the risks associated with WFU: acreage burned under WFU does not count towards accountable target accomplishment. This leads to suppressing candidate WFU fires inside prepared prescribed burn areas. In addition, this lack of credit poses a challenge to meeting hazardous fuel reduction targets during seasons that offer WFU opportunities but provide limited prescribed burning windows because of fuel conditions. If WFU, a tool that accomplishes both agency goals, is to increase, then the perverse disincentive to authorizing WFU requires rectification.

4. "Teach by doing"

Respondents in areas with a history of prescribed natural fire and wildland fire use indicated that their local public neutrally (if not favorably) on WFU. Drawing attention to successfully managed WFU events and their consequent benefits to local ecosystems may provide the most effective means to curry public support.

5. CONCLUSION

The position of line officer in the US Forest Service draws people with a strong commitment to working for the good of the land. As with many public sector careers, there are few benefits other than satisfying a personal land stewardship ethic – a characteristic that holds true in the context of using lightning ignitions to restore fire to the landscape. This study suggests that authorization of WFU by district rangers primarily stems from their personal commitment to restoring fire for the good of the land, despite multiple disincentives. If national policy mandates restoring fire as a natural process, then implementation should not rely uniquely on those willing to take risks for their personal ethic. Recommendations presented in this paper suggest ways to mitigate obstacles to 'go,' the keystone of using WFU as part of a full suite of fire and fuel management options.

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APPENDIX A: QUESTIONNAIRE

Italicized headings identify question grouping.

Eligibility

1. In the last 3 fire seasons, since 2002, have you had any lightning starts in the WFU-approved area?
   - Yes
   - No

IF RESPONDENT ANSWERS 'NO' ONLY ASK QUESTIONS UNDERLINED.

2. Thinking about the last 3 fire seasons, since 2002, about how many lightning starts in the WFU-approved area have you managed as WFU?
   - All
   - Most
   - About half
   - Few
   - None

3. Do you have WFU authorized outside of the wilderness?
   - In LRMP/FMP revision
   - Yes
   - No

Program value

4. Where do you place returning fire to the landscape as a land management goal?
   - Very important
   - Somewhat important
   - Neither important nor unimportant
   - Somewhat unimportant
   - Very unimportant

5. Mechanical treatments, prescribed burning and WFU can all help reintegrate fire into the landscape. To what extent, if at all, do you think that WFU is an effective tool for returning fire to the landscape?
   - Very great extent
   - Some extent
   - Small extent
   - Not at all

6. To what extent, if at all, does the WFU program meet your wilderness management objectives?

Very great extent
Some extent
Small extent
Not at all

Environmental factors

7. In the last three fire seasons, since 2002, were there any high-priority, non-fire projects in your area that caused you to consider suppressing an eligible WFU fire?

PROMPT: For example, grizzly bear DNA testing in Region 1.

Yes
No

IF Y, THEN 8, ELSE 9.

8. To what extent, if at all, did these projects influence your go/no go decision?

Very great extent
Some extent
Small extent
Not at all

9. To what extent, if at all, does time of year influence your go/no go decision?

Very great extent
Some extent
Small extent
Not at all

10. Do the areas approved for WFU on your district share boundaries with other administrative units or landowners?

Yes
No

IF Y, THEN 11, ELSE 12.

11 Do you have appropriate agreements in place with adjacent units or landowners in case a WFU would cross boundaries?

Yes
No

12. To what extent, if at all, does proximity to WFU-approved area boundaries affect your go/no go decision?
    Very great extent
    Some extent
    Small extent
    Not at all

13. To what extent, if at all, does concern for public support affect your go/no go decision?
    Very great extent
    Some extent
    Small extent
    Not at all

14. To what extent, if at all, does concern for public perception of air quality influence your go/no go decision?
    Very great extent
    Some extent
    Small extent
    Not at all

15. To what extent, if at all, does concern for public perception of risk from the fire escaping influence your go/no go decision?
    Very great extent
    Some extent
    Small extent
    Not at all

Fire experience

16. Were you the line officer for any Type 1 or 2 suppression fires?
    Yes
    No

17. About how big did the most recent Type 1 or 2 fire get?
    ACRES _____

18. If there have been more than one Type 1 or 2 fire on your unit since 2002, how many have you had?
    NUMBER OF FIRES_____

19. The last few fire seasons have had some of the most active fire behavior in recent history. In the last 3 fire seasons, since 2002, have you had any escaped prescribed fires on your unit?

Yes
No

20. In the last 3 fire seasons, since 2002, can you think of an instance where you authorized a fire to be managed as WFU and the fire was later converted to a suppression fire?

Yes
No

21. Often weather, fuel conditions, resource availability, public and firefighter safety, or money available to return the fire to prescription will change a prescribed fire to a suppression fire. Can you give me an idea of what made the fire go from prescribed to suppression?

ANSWER _____

22. Again, often weather, fuel conditions, resource availability, maximum manageable area size, public and firefighter safety, or cost will cause management to change a WFU event to a suppression one. Do you happen to recall what determined the shift from WFU to suppression?

ANSWER _____

23. To what extent, if at all, do you think it's possible to manage a non-suppression fire, whether prescribed or fire use, to meet your objectives?

Very great extent
Some extent
Small extent
Not at all

24. What do you think is needed to make it possible to manage a non-suppression fire, either prescribed or fire use, to meet your objectives?

ANSWER _____

District communication

25. How, if at all, do non-fire program areas contribute to the WFU program before fire season?

ANSWER _____

26. How often, if ever, do you feel that you and your FMO share similar attitudes about what constitutes an appropriate go/no go decision?

Always
Most of the time
About half the time
Occasionally
Never

27. Managing a WFU event can involve monitoring, taking some suppression actions, calling in national management teams, or converting the fire to a suppression event. To what extent, if at all, do you think your local WFU managers will make appropriate tactical decisions for a WFU event in your area?

Very great extent
Some extent
Small extent
Not at all

28. Managing a WFU event can involve monitoring, taking some suppression actions, or converting the fire to a suppression event. To what extent, if at all, do you think national Fire Use management teams will make appropriate tactical decisions for a WFU event in your area?

Very great extent
Some extent
Small extent
Not at all

Forest Service policy and protocol

29. How often, if ever, do you use fuels budget money (WFHF) to pay for WFU?

Always
Most of the time
About half the time
Occasionally
Never

30. To what extent, if at all, does using the G code for WFU help meet your district's fuels targets?

Very great extent
Some extent
Small extent
Not at all

31. To what extent, if at all, do you think that WFU is a cost-effective way of achieving fuels targets?
    Very great extent
    Some extent
    Small extent
    Not at all

32. To what extent, if at all, does using WFU to achieve targets influence your decision to go/no go?
    Very great extent
    Some extent
    Small extent
    Not at all

33. Suppose BAER funds were available to help rehab infrastructure damaged during a WFU event. To what extent, if at all, would having these funds available influence your go/no go decision?
    Very great extent
    Some extent
    Small extent
    Not at all

34. To what extent, if at all, do you think that your FMP contains useable information for the go/no go decision?
    Very great extent
    Some extent
    Small extent
    Not at all

35. To what extent, if at all, do you think that the Wildland Fire Implementation Plan Stage 1 process aids the go/no go decision?
    Very great extent
    Some extent
    Small extent
    Not at all

36. How often, if ever, do you visit the Wildland Fire Lessons Learned Center website?
    Very often
    Often
    Not often
    Never

37. To what extent, if at all, do you feel that information provided on this website assists your go/no go decision?

Very great extent
Some extent
Small extent
Not at all

38. To what extent, if at all, do you feel that you have access to the resources you need to manage a fire as WFU?

Very great extent
Some extent
Small extent
Not at all

39. Suppose you decide to 'go' on a WFU event that later damages other values at risk. In your opinion, will this have any negative impact on your job?

Yes
No

40. The way fires progress can have repercussions on decision-makers' careers. This has come to a lot of folks' attention after the Cerro Grande fire in Bandelier National Monument in 2000, and more recently with the Cramer fire on the Salmon-Challis in 2003. To what extent, if at all, does concern over negative impacts on your career influence your go/no go decision?

Very great extent
Some extent
Small extent
Not at all

41. Do you have any incentives use WFU?

Yes
No

42. IF Y, What are they?

ANSWER _____

43. Do you have any disincentives to use WFU?

Yes
No

44. IF Y, What are they?

ANSWER _____

45. Thinking about the decision making behind the go-no go decision on WFU as a whole, what are the top 3 factors affecting your decision on every project?
ANSWER _____

Demographics

46. Would you characterize yourself as more of a risk-taker or a risk-avoider?
Risk-taker
Risk-avoider
Risk-neutral

47. What fire qualifications do you have?
ANSWER_____

48. Have you had any formal fire ecology classes?
Yes
No

49. IF Y,
College
Agency
Both

50. When did you start with the USFS?
YEAR_____

51. When did you start in your current position?
YEAR _____

52. Prior to this position, were you a line officer?
Yes 1
No 0

53. IF Y, How long?
ANSWER_____

54. What are your career goals?
District-level management
Forest-level management
Region-level management
National-level management
Other

55. What is your professional background?

Recreation
Timber
Engineering
Fire
Resource Specialist
Other

56. What is the highest level of education you have?

High-school
Vocational school
Some college
Associates
Bachelors
Some grad school
Masters
Doctorate

APPENDIX B: HOW CART WORKS

Classification and regression tree analysis (CART) uses repeated binary partitioning to provide an accurate classifier for a data set or to uncover a predictive structure (Breiman et al. 1984). CART analysis programs contain algorithms that search all possible binary split levels in all the independent variables. CART analysis then selects the split that isolates the largest pure class of the dependent variable (Gini splitting criterion, Lewis 2000). This process constructs a tree with branches occurring at decision nodes. These nodes split into "children," with all cases in the data set that meet the node's splitting rule going to the left child and the remaining cases going to the right child. Splitting continues until pure nodes result (terminal nodes). This is the maximal tree (Breiman et al. 1984).

This maximal tree tends to overfit the data used to construct the tree, with the analysis modeling both true patterns and noise in the data. To increase the tree's applicability to different cases, the maximal tree can be pruned based on a complexity parameter. This metric indicates how much additional accuracy a split must add to the entire tree to warrant the added complexity (Lewis 2000). The pruning process yields the optimal tree that attempts to balance accuracy for the data on hand with accuracy on future data.

Ideally, a 'learning' data set is used to grow the tree and a separate 'test' data set determines the tree's accuracy. While large data sets (n>3000) allow isolating learning and test portions, smaller data sets do not have this option. In order to test the

performance of a tree constructed using a small data set, CART relies on cross-validation (Steinberg and Colla 1997).

Cross-validation estimates the classification accuracy of the full tree based on its ability to classify independent test sets. The data are partitioned into V independent groups that include the entire data set. In the first iteration, the first group is reserved as a test set and the remaining V-1 groups build a tree. The accuracy of this tree is then assessed based on how well it classifies the district rangers reserved in the first partition. This process repeats V times. These separate models' average performance estimates the overall model's accuracy. The cross-validation process also determines the complexity parameter level so that the end model does not overfit the data (Lewis 2000). The tree construction and cross-validation processes result in a model that isolates the independent variables responsible for classifying the dependent variable with the least impurity in the classification. New cases can then be dropped down the tree. At each node, the new case is evaluated against the splitting rule, and then moved on to the next node until the case reaches a terminal node and can be classified.

When classifying new cases, CART identifies 'surrogate' splitters to move a case with missing values down the tree. These surrogate splitters are independent variables whose distributions follow a similar pattern to that of the primary splitter. The surrogate split is defined as the one that most accurately predicts the action of the primary splitter on a case by case basis (Breiman et al. 1984, Steinberg and Colla 1995).

APPENDIX C: COLLAPSED VARIABLE KEY

Column 2 contains the question number. Columns 3 through 6 contain the post-coded answers that were included in the new variables. A negative sign indicates that the response's score was subtracted in the new variable's construction.

1	2	3	4	5	6
Variable name	Questions re-scaled to 0-1	Question 24	Question 42	Question 44	Question 45
STFTRST	25, 26, 27, 28				
EXT	8, 9, 12	11, 12, 16, 17, 19		1, 2, 12, 13, 14, 15, 22	
FIRE	16, 18, 19, 20, 47, 48				
PRTCL	34, 35	5 (-), 6 (-)	14	11 (-)	16
AGSPRT	30, 37, 39 (-), 40 (-), 41, 43 (-)	15 (-)	6, 10, 12, 13, 16	5 (-), 6 (-), 10 (-), 16 (-), 18 (-), 19 (-), 23 (-)	22 (-), 27 (-), 24
STAFFLVL	38	3, 13, 14		7	6
PUBPERC	13 (-), 14(-) 15(-)	2		3(-), 4(-), 20(-)	4(-), 5(-), 12(-)
PROGVAL	4, 5, 6, 23, 31.		1, 2, 4, 5, 11, 17		

APPENDIX D: SURVEY RESULTS BY REGION

Eligibility

	Question	Response	Total	R1	R3	R4
1	Opportunity to use WFU	Yes	**46**	19	11	16
		No	**4**	2	1	1
2	Number of lightning strikes managed as WFU	All	**5**	1	2	2
		Most	**7**	4	1	2
		Half	**10**	5	3	2
		Few	**15**	4	5	6
		None	**9**	5	0	4
3	Ability to use WFU outside of wilderness	In plan revision	**4**	0	1	3
		Yes	**29**	6	10	13
		No	**16**	15	0	1

Attitude towards WFU program

	Question	Response	Total	R1	R3	R4
4	Importance of returning fire to the landscape	Very important	**45**	21	12	12
		Somewhat important	**5**	0	0	5
		Neutral	**0**	0	0	0
		Somewhat unimportant	**0**	0	0	0
		Very unimportant	**0**	0	0	0
5	Extent to which WFU is an effective tool for returning fire to the landscape	Very great extent	**30**	12	11	7
		Some extent	**20**	9	1	10
		Small extent	**0**	0	0	0
		Not at all	**0**	0	0	0
6	Extent to which WFU meets wilderness management objectives	Very great extent	**21**	12	3	6
		Some extent	**18**	7	4	7
		Small extent	**6**	1	1	4
		Not at all	**2**	0	2	0

External factors

	Question	Response	Total	R1	R3	R4
7	High-priority, non-fire projects	Yes	14	5	3	6
		No	33	15	8	10
8	Extent to which these affect go/no go decision	Very great extent	7	2	2	3
		Some extent	2	1	1	0
		Small extent	2	1	0	1
		Not at all	0	0	0	0
9	Extent to which time of year influences go/no go decision	Very great extent	31	10	10	11
		Some extent	12	8	0	4
		Small extent	2	1	0	1
		Not at all	1	0	1	0
10	Boundaries with other units or landowners	Yes	48	21	12	15
		No	2	0	0	2
11	Appropriate agreements in place	Yes	39	18	10	11
		No	8	3	1	4
12	Extent to which proximity to WFU-approved area boundary affects go/no go decision	Very great extent	21	11	6	4
		Some extent	24	8	5	11
		Small extent	1	0	0	1
		Not at all	0	0	0	0
14	Extent to which public perception of air quality affects go/no go decision	Very great extent	12	2	5	5
		Some extent	22	11	3	8
		Small extent	9	6	1	2
		Not at all	3	0	2	1
15	Extent to which public perception of risk from the fire escaping affects go/no go decision	Very great extent	11	2	4	5
		Some extent	22	13	7	2
		Small extent	11	4	0	7
		Not at all	2	0	0	2

Fire experience

	Question	Response	Total	R1	R3	R4
16	Line officer for Type 1 or 2 fires	Yes	**34**	20	7	7
		No	**16**	1	5	10
17	Acreage of largest Type 1 or 2 fire	Mean	**16421**	31063	11575	10125
		Median	**8000**	11000	5500	9500
18	Total number of Type 1 or 2 since 2002	Mean	**2.3**	2.4	0.5	2.5
		Median	**2**	2.5	0	2.5
19	Escaped prescribed fire on unit since 2002	Yes	**9**	3	3	3
		No	**41**	18	9	14
20	WFU converted to suppression on unit since 2002	Yes	**9**	4	2	3
		No	**31**	13	9	9
21	Reason for escaped prescribed fire (columns do not add up to total reported for #19 because of multiple reasons for escape)	Fire behavior	**2**	2	0	0
		Weather	**5**	0	3	2
		Resource availability	**1**	1	0	0
		Other	**2**		1	1
22	Reason for converted WFU (columns do not add up to total reported for #5 because of multiple reasons for conversion)	Merged with suppression fire	**1**	1	0	0
		Weather	**2**	0	0	2
		Resource availability	**3**	3	0	0
		MMA	**4**	2	1	1
		Cost	**2**	1	0	1
		Other	**2**	1	1	0
23	Extent to which think it's possible to manage non-suppression fire to meet objectives	Very great extent	**27**	12	6	9
		Some extent	**22**	9	6	7
		Small extent	**1**	0	0	1
		Not at all	**0**	0	0	0
24	What is needed to make it possible to manage a non-suppression fire to meet objectives	Resource availability	**14**	8	3	3
		Acceptable fire danger indices	**7**	3	1	3
		Quality people	**7**	1	2	4
		Public support	**6**	3	1	2
		Authority	**5**	3	2	0
		Time of year	**2**	1	1	0
		Location	**1**	1	0	0
		Pre-treatments	**1**	1	0	0
		Agency support	**1**	0	0	1
		Weather	**1**	0	0	1
		Other	**6**	0	2	4

District communication and trust

	Question	Response	Total	R1	R3	R4
25	Non-fire program area contribution to WFU pre-fire season	More than one annual training or planning activity	**4**	1	3	0
		One annual training or planning activity	**9**	5	1	3
		One-time input to training or planning	**13**	5	3	5
		Favorable attitude	**6**	2	1	3
		No pre-season contribution	**15**	6	4	5
26	Shared attitude with FMO about appropriate go/no go decision	Always	**14**	7	4	3
		Most of the time	**33**	14	8	11
		About half the time	**1**	0	0	1
		Occasionally	**0**	0	0	0
		Never	**0**	0	0	0
27	Belief that local WFU managers will make appropriate decisions	Very great extent	**34**	13	10	11
		Some extent	**14**	7	2	5
		Small extent	**1**	1	0	0
		Not at all	**0**	0	0	0
28	Belief that national FUMTs will make appropriate decisions	Very great extent	**30**	16	3	11
		Some extent	**15**	4	8	3
		Small extent	**3**	1	1	1
		Not at all	**0**	0	0	0

Budget considerations

	Question	Response	Total	R1	R3	R4
29	Frequency that fuels budget money is used to pay for WFU	Always	**1**	0	0	1
		Most of the time	**3**	1	1	1
		About half the time	**0**	0	0	0
		Occasionally	**1**	0	0	1
		Never	**26**	10	7	9
		Don't know	**7**	4	3	0
30	Extent to which G code helps meet districts fuels targets	Very great extent	**5**	2	3	0
		Some extent	**5**	2	2	1
		Small extent	**7**	4	0	3
		Not at all	**17**	6	4	7
		Don't know	**6**	2	3	1
31	Extent to which WFU is a cost-effective way of achieving fuels targets	Very great extent	**20**	10	7	3
		Some extent	**20**	11	3	6
		Small extent	**8**	0	1	7
		Not at all	**2**	0	1	1
32	Extent to which using WFU to achieve targets influences go/no go decision	Very great extent	**2**	1	1	0
		Some extent	**3**	1	1	1
		Small extent	**14**	6	4	4
		Not at all	**25**	11	5	9
33	Extent to which having BAER funds available would influence go/no go decision	Very great extent	**5**	2	1	2
		Some extent	**8**	4	3	1
		Small extent	**13**	5	2	6
		Not at all	**24**	10	6	8

Protocol and process

	Question	Response	Total	R1	R3	R4
34	Extent to which FMP contains useable information for go/no go decision	Very great extent	22	11	3	8
		Some extent	24	8	7	9
		Small extent	4	2	2	0
		Not at all	0	0	0	0
35	Extent to which WFIP1 process aids go/no go decision	Very great extent	21	9	4	8
		Some extent	25	10	7	8
		Small extent	1	1	0	0
		Not at all	0	0	0	0
36	Frequency of visits to Wildland Fire Lessons Learned Center website	Very often	1	0	1	0
		Often	4	1	2	1
		Not often	20	8	7	5
		Never	24	11	2	11
37	Extent to which information provided on this website assists go/no go decision	Very great extent	2	0	2	0
		Some extent	11	4	2	5
		Small extent	9	5	4	0
		Not at all	0	0	0	0
38	Extent to which have access to resources needed to manage fire as WFU	Very great extent	21	8	5	8
		Some extent	24	11	6	7
		Small extent	5	2	1	2
		Not at all	0	0	0	0
39	Negative impact on job if authorize a WFU that damages values at risk	Yes	24	9	6	9
		No	24	11	5	8
40	Extent to which concern for negative impacts on career influences go/no go decision	Very great extent	3	1	0	2
		Some extent	8	2	1	5
		Small extent	20	13	3	4
		Not at all	13	2	7	4
41	Incentives to use WFU	Yes	45	21	9	15
		No	5	0	3	2
42	Incentives	Ecological/stewardship	41	19	9	12
		Wilderness management tool	2	2	0	0
		Fuel reduction	2	1	0	1
		Cost	3	1	1	1
		Safety	2	1	0	1
		Agency policy	2	1	0	1
		Agency credit	2	1	0	1
		G code	2	0	1	1
		In plan	2	0	1	1
		Historical use	1	0	1	0
		Regional priority	2	0	1	1
		Teach by doing	1	0	0	1
43	Disincentives to use WFU	Yes	32	14	6	12
		No	18	7	6	5

	Question	Response	Total	R1	R3	R4
44	Disincentives	Risk of unknown	8	2	0	6
		Public perception	7	5	0	2
		Career impacts	7	2	1	4
		External conditions	6	1	2	3
		Potential impacts to private land	4	3	0	1
		Political climate	4	4	0	0
		Smoke	3	1	0	2
		Resource availability	3	3	0	0
		No credit	3	0	1	2
		Resource impacts	3	2	0	1
		Proximity to WUI	2	2	0	0
		Suppression paradigm	2	0	1	1
		Pressure to meet prescribed burn targets	2	0	1	1
		Planning process	2	0	2	0
		Other	7	1	1	5
45	Top three factors influencing go/no go decision on every project	Fire danger indices	21	10	4	7
		Resource availability	20	7	7	6
		Location	16	10	1	5
		Time of year	16	7	4	5
		Impacts to resource	13	3	5	5
		Safety	11	4	3	4
		Impacts to private land	8	5	2	1
		Political climate	4	1	1	2
		Impacts to recreators	3	1	0	2
		Fuel type	3	1	1	1
		Potential to exceed MMA	3	2	0	1
		Preparedness level	3	2	0	1
		Smoke	2	0	0	2
		Public perception	1	0	0	1
		In plan	1	1	0	0
		Impacts to improvements	1	1	0	0
		Previous treatments/fires	1	0	1	0
		Gut	1	1	0	0
		Experience	1	1	0	0
		Resource objectives	1	0	1	0
		Proximity to T&E species	1	0	1	0
		Cost	1	0	1	0
		Weather	1	0	0	1
		Ignition type	1	0	0	1
		Documentation	1	0	0	1
		Other activity (fire and other)	1	0	0	1

Demographics

	Question	Response	Total	R1	R3	R4
46	Risk avoider or risk-taker	Risk neutral	6	1	4	1
		Risk avoider	8	3	0	5
		Risk taker	36	17	8	11
47	Fire-line qualifications	Division supervisor +	11	4	4	3
		Crew boss to division supervisor	7	1	2	4
		On IMT, no fire-line qualifications	12	5	2	5
		Agency administrator to firefighter 1	16	9	4	3
		None	4	2	0	2
48	Formal fire ecology classes	Yes	36	17	11	8
		No	14	4	1	9
49	Fire ecology class location	College and agency	18	9	4	5
		College/university	13	7	3	3
		Agency	5	1	4	0
50	Time with USFS	Mean	24.3	22.3	15.8	26.5
		Median	25	21	15.5	27
51	Time in current position	Mean	5.6	5.2	4.25	5.6
		Median	4	4	2.5	4
52	Prior line officer experience	Yes	23	10	7	6
		No	27	11	5	11
53	Length of prior line officer experience	Mean	5.2	3.9	1.5	5.1
		Median	3	2.5	1.3	3.5
54	Career goals	District-level management	30	14	6	10
		Forest-level management	14	4	5	5
		Region-level management	3	2	0	1
		National-level management	2	1	1	0
		Other	1	0	0	1
55	Professional background	Recreation	3	2	0	1
		Timber	17	4	6	7
		Engineering	1	1	0	0
		Fire	0	0	0	0
		Resource specialist	21	9	6	6
		Other	8	9	0	3
56	Education level	Bachelors degree	33	14	7	12
		Some graduate school	9	4	1	4
		Masters degree	8	3	4	1
	Sex	Female	11	5	5	1
		Male	39	16	7	16